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URANIUM IN VIRGINIA

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Introduction

During the past year there has been an appreciable amount of interest in various parts of Virginia concerning the possibility of finding deposits of uranium that would be of commercial significance. An article concerning this subject is timely and may provide sufficient information to encourage further field investigation in certain areas and at the same time to prevent unwarranted optimism and undue excitement.

Uranium Minerals

Uranium minerals may be grouped into two classes: primary and secondary. Primary ones have been formed by heated solutions coming up from deep within the earth. Secondary ones have been formed by changes in primary minerals caused by the action of weathering, ground waters or by other natural processes.

Primary uranium minerals are usually found in vein deposits or pegmatites. Those found in pegmatites are rarely in sufficient quantity or concentration to be of commercial importance. The most important primary uranium mineral is pitchblende. It usually is found in vein deposits and is commonly associated with sulphide minerals of such metals as silver, cobalt, nickel, iron, lead, zinc, or copper. Pitchblende is black in color, metallic in luster, heavier than iron and about as hard as steel. It contains from 50 to 80 per cent U_3O_8.

Secondary uranium minerals usually occur as earthy or powdery masses or as groups of tiny crystals or flat plates. They are usually bright colored; yellow, orange, and green are common. These minerals have been found in all types of rocks--igneous, sedimentary and metamorphic. They contain a lower percentage of uranium than pitchblende. Of the many secondary uranium minerals only four are at all common or important. Carnotite and tyuyamunite (closely related in composition, physical properties, and occurrence) are the best known and most important of the group. They are bright yellow and occur commonly as soft earthy masses filling the spaces between grains of other minerals in rocks, particularly in sandstones. Autunite is a bright lemon or sulphur yellow mineral and occurs as small flat crystals or as thin coatings in rock fractures. When exposed to ultraviolet light it fluoresces a bright yellow or apple green. Torbernite is bright green in color and sometimes, but not always, fluoresces bright green. It occurs in flat, square crystals.

Many other radioactive minerals are known; they will not be discussed here. The interested reader may learn about them by consulting references 1 and 3 listed at the end of this article.

Geological Occurrences of Uranium Minerals

Uranium minerals have been found in all of the three chief classes of rocks--igneous, sedimentary, and metamorphic; and probably in rocks of all geologic ages from Pre-Cambrian to Recent. Veins of pitchblende have been found in fractures and as disseminations in all types of rocks, especially in highly folded and metamorphosed rocks. Sandstones, shales, and limestones may contain uranium minerals, although deposits of commercial grade in limestones are rare. Deposits in sandstones are widely distributed, and it is from these that production from secondary minerals, carnotite and tyuyamunite particularly, is chiefly obtained. The mineralization occurs between grains and in various types of fractures. Mineralization in shales is more uniformly distributed than in sandstones but is usually lower in percentage, hence deposits in shales are much lower in grade.

In summary, the best grades of commercial deposits of uranium are most likely to be found in fractured or faulted metamorphic and igneous rocks and in permeable sandstones. In May 1954, Dr. Donald L. Everhart of the U. S. Atomic Energy Commission made the following statement to the members of the Geology Section, Virginia Academy of Science: "Particularly favorable geologic environments include continental conglomerate, arkosic sandstone, or mudstone formations, especially those high in carbonized plant matter, and equivalent metaconglomerate, quartzite, schists, or paragneiss formations. Three hydrothermal deposits which are favorable are: siliceous veins carrying pyrite and galena, siliceous veins rich in titanium, and nickel-cobalt-copper-silver veins."

Detection of Radioactive Minerals

It is not within the scope of this article to discuss details of detection of radioactivity. This information may be obtained by consulting references 2 and 3 listed at the end of the article. It will suffice to say that for serious prospecting a good scintillation counter (price about $500.00) is essential. A good Geiger counter (price about $150.00) is desirable as a supplement to the scintillation counter, or the Geiger counter can be used without the scintillation counter if the probe is used in close proximity to the source of radiation. The scintillation counter can be used from a moving vehicle; the ordinary hand-operated Geiger counter cannot. A word of caution would not be amiss at this point. Care should be used in interpretation of readings noted on either of these instruments. Normal background radiation in Virginia is about 0.025 MR/HR (milliroentgens per hour). Readings of 2 to 4 times background (0.050 MR/HR to 0.100 MR/HR) are frequently noted in areas of igneous rocks and in some sandstones. Such increases over normal background are actually very slight and rarely indicate a deposit of significance. However any area showing readings of as much as 4 times background should be investigated carefully to ascertain if a source of higher radiation is in the vicinity.

It should be further noted that thorium affects scintillation and Geiger counters in the same manner as uranium. Only chemical tests can determine which element is present.

Geology of Radioactive Deposits in Virginia

Field reconnaissance studies of radioactivity were conducted during part of the summer of 1954 by the writer as a consultant for the U. S. Atomic Energy Commission. This study consisted primarily of road traverse with a scintillation counter mounted in a car. Obviously every mile of road in the State was not included in the traverse, but areas of most favorable geology were chosen for investigation. These included areas of metamorphic and igneous rocks of the Piedmont and Blue Ridge provinces, the Cambrian and Devonian sandstones and shales of the Valley and Ridge Province, and the Lower Mississippian and Lower Pennsylvanian sandstones of that province.

To date no deposits of uranium of commercial significance have been discovered in Virginia. However, a few areas have shown anomalous radioactivity and might be worthy of further and more intensive investigations.

Between Roanoke and Newcastle, several exposures of Chemung sandstone show Geiger counter readings up to 0.15 MR/HR. Radioactivity is concentrated in definite beds of the formation. Radioactivity in similar amounts is present in this formation south of Newport in Montgomery County.

Three areas of interesting radioactivity were located in the vicinity of Pulaski. All three are at approximately the same horizon in the Price sandstone, below a prominent coal bed and about 100 feet above the bottom of the formation; maps indicate that they are within a few hundred feet of a fault.

On the south side of Brushy Mountain between Sharon Springs, Bland County, and Burkes Garden, Tazewell County, a prominent exposure of Price sandstone gives readings up to 0.30 MR/HR on the scintillation counter in contact with yellowish-brown shaly sandstone. Limonite-filled fractures and limonite concretions are common in the zone of highest radioactivity. The mapped trace of the Saltville-Bland fault strikes N. 50° E. a few hundred yards south of the radioactive outcrop.

Between Bluefield and Tazewell, the Price sandstone was examined at four localities. At three of these, radioactivity of only twice background was noted. The fourth locality, in the vicinity of Bailey Church, gives Geiger counter readings up to 0.150 MR/HR. The trace of the St. Clair fault, as mapped, extends parallel to the strike of the sandstone and is only a few hundred yards south of the zone of radioactivity.

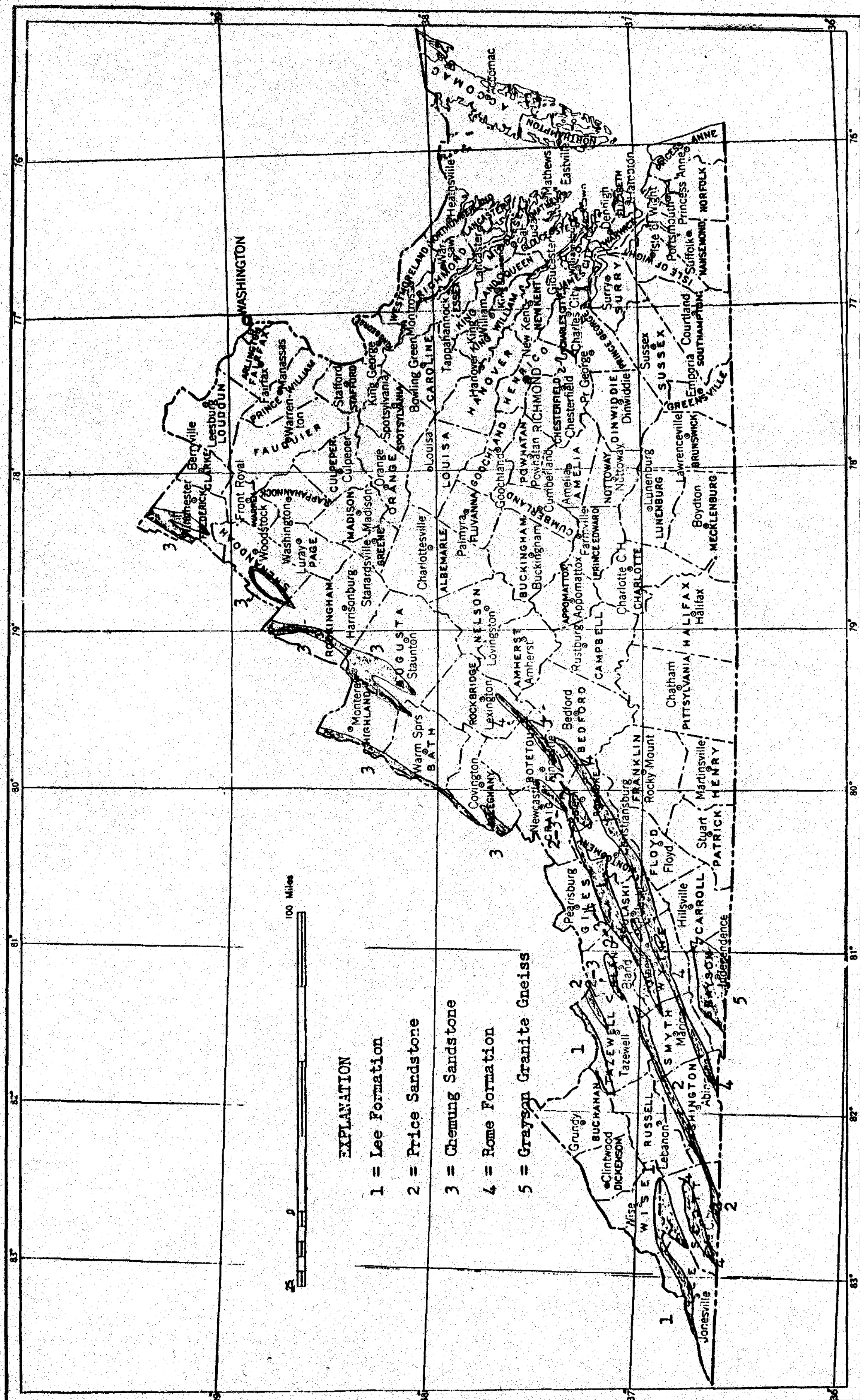
Between Buena Vista, Rockbridge County, and Roanoke, all exposures of the Cambrian Rome formation show slightly anomalous radioactivity, usually of a magnitude of two or three times background.

The anomalous radioactivity noted in the Blue Ridge and Piedmont during reconnaissance has been accounted for by the presence of thorium-bearing minerals -- allanite in the Blue Ridge and monazite in the Piedmont.

Between Culpeper and Charlottesville, two localities of anomalous radioactivity have been found. One is about eight miles west of Culpeper. The radioactive rock is the Lovingston granite gneiss consisting principally of biotite-quartz monzonite and augen gneiss, intrusive into the Lynchburg gneiss and hornblende gabbro. Several narrow strips or disconnected zones in a road cut give Geiger counter readings as high as 2.5 MR/HR. Analyses show the presence of monazite, and hence thorium, as the chief source of radioactivity. Another occurrence with similar geology and radioactivity is located near the new Charlottesville airport.

East of Chestnut Knob, between Ridgeway and Spencer, Henry County, the Wissahickon schist exhibits appreciable radioactivity. Highest instrument readings are obtained in zones of magnetite concentration. Consistent readings of 0.4 MR/HR are obtained for several hundred yards along road cuts and maximum readings of 1.6 MR/HR are found in the zones of magnetite. Unfortunately, as in the Culpeper and Charlottesville areas, the radioactivity is due primarily to thorium in monazite.

In western North Carolina and eastern Tennessee, areas of Cranberry granite, as mapped by Keith and others, have been found to contain deposits of uranium minerals of interest. Veins and disseminations of pitchblende have been located, but to date the real significance of these occurrences has not been determined. It is worthy of note that on the geologic map of Virginia the following statement is made concerning the Grayson granite gneiss: "porphyritic biotite granite gneiss containing coarse pink to white feldspar phenocrysts, with numerous dark schistose layers and cut by pegmatites; probably equivalent to part of Cranberry granite of Keith." In the vicinity of Independence, Grayson County, road cut exposures of Grayson granite gneiss show anomalous radioactivity as high as 0.40 MR/HR, but no concentrated mineralization was found during reconnaissance. Because of the petrographic and structural similarity between the Grayson granite



Major outcrop areas of formations considered most worthy of testing for uranium mineralization.

gneiss of Virginia and the Cranberry granite of North Carolina and Tennessee, detailed examination of areas of Grayson granite gneiss might be warranted.

It may be significant to note that most of the bedrock in the State is covered by a soil mantle varying from a few to many feet in thickness and that most of the spots at which anomalous radioactivity has been encountered are in rock exposures in road cuts or narrow bottoms of streams. Hence it is logical to suppose that radioactive outcrops located to date represent only a small per cent of the radioactive rocks underlying the State. Likewise it is illogical to assume that the few radioactive outcrops now known necessarily constitute the highest concentrations of uranium that exist in the State of Virginia.

Summary

The results of preliminary reconnaissance for uranium in Virginia would seem to indicate the validity of the following statements:

1. There is a genetic relationship between uranium mineralization and faulting or shearing.

2. The Grayson granite gneiss is worthy of further examination.

3. Areas of Price sandstone should be more thoroughly tested.

4. Areas of the Rome formation might be more extensively examined.

5. Areas of Pottsville or Lee formations might warrant further study.

6. Formations equivalent to the Chemung have shown slight anomalous radioactivity.

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Selected References

1. Prospecting for Uranium: U. S. Atomic Energy Commission and U. S. Geological Survey. For sale by Superintendent of Documents, Government Printing Office, Washington 25, D. C. (45 cents).
2. Prospecting with a Counter: U. S. Atomic Energy Commission. For sale by Superintendent of Documents, Government Printing Office, Washington 25, D. C. (30 cents).
3. Minerals for Atomic Energy: Robert D. Nininger, Van Nostrand, 1954.
4. Nuclear Geology: A Symposium on Nuclear Phenomena in the Earth Sciences, John Wiley and Sons, 1954.
5. Geologic Map of Virginia: Wilbur A. Nelson, State Geologist, Virginia Geological Survey, 1928.
6. Geologic Map of the Appalachian Valley in Virginia: Charles Butts, Virginia Geological Survey, 1933.

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NEXT ISSUE OF VIRGINIA MINERALS

The October issue of VIRGINIA MINERALS will discuss current manganese operations in Virginia, a particularly timely topic. Edwin O. Gooch of the division staff will be the author.

URANIUM-PRODUCING AREAS

The map on page 5 shows some of the most important uranium deposits in North America, divided into two classes: those predominantly of primary uranium minerals and those predominantly of secondary uranium minerals (see page 1). Of these deposits, as far as is known, the most significant are at Beaverlodge and Port Radium in Canada and on the Colorado Plateau in the United States. Deposits of uranium of small tonnage or of low grade are scattered widely throughout the United States. The discovery of uranium minerals by no means assures the presence of a commercial deposit. And, of course, the discovery of radioactive minerals by no means assures the presence of uranium.

Shinkolobwe, in the Belgian Congo, has to date produced the largest amount of uranium in the world. Other areas outside North America of large uranium production are Joachimsthal in Czechoslovakia and East Germany, Rum Jungle and Radium Hill in Australia, the Massif Central in France, and Urgeirica in Portugal. Before the development of the Colorado Plateau deposits by far the majority of world uranium production was from primary vein deposits.

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HOW RADIATION DETECTORS WORK

The two instruments commonly used in prospecting for radioactive minerals are the Geiger counter and the scintillometer, with the Geiger counter the more popular, largely because of its considerably lower price. Geiger counters vary widely, but they are all built around the Geiger-Mueller tube. This tube, made of glass or metal, has a thin wire running its length in the center, and a cylindrical metal electrode. The tube is filled with gas under low pressure, and a high voltage is applied between the wire and the tube wall. The center wire and the electrode are insulated from each other and are so connected in the circuit that the high voltage current passes momentarily between them when radiations penetrate the tube and make the gas conductive to electricity for a small fraction of a second. Each high voltage discharge registers as a click on the headphones or as a reading on the meter. Batteries to supply power and an amplifier to strengthen the pulse are also parts of the instrument.

Most portable Geiger counters have gamma ray counter tubes, which means that they are affected by only one of the three types of radiation from uranium minerals. Even the best Geiger tube is very inefficient in detecting gamma radiation, reacting to less than one per cent of the gamma rays penetrating it. The size of the sensitive part of the tube is the main factor in effectiveness.

The scintillometer or scintillation counter records the flashes of light (scintillations) produced in certain crystals on penetration by gamma rays. The crystal is attached to the end of a light sensitive tube; scintillations produced in the crystal are transmitted from the tube to an amplifier and then to a recording meter. Because the crystal reacts to a far larger percentage of the gamma rays which penetrate it than does the Geiger tube, the scintillometer is a much more sensitive device. The size of the crystal is the main factor in effectiveness.

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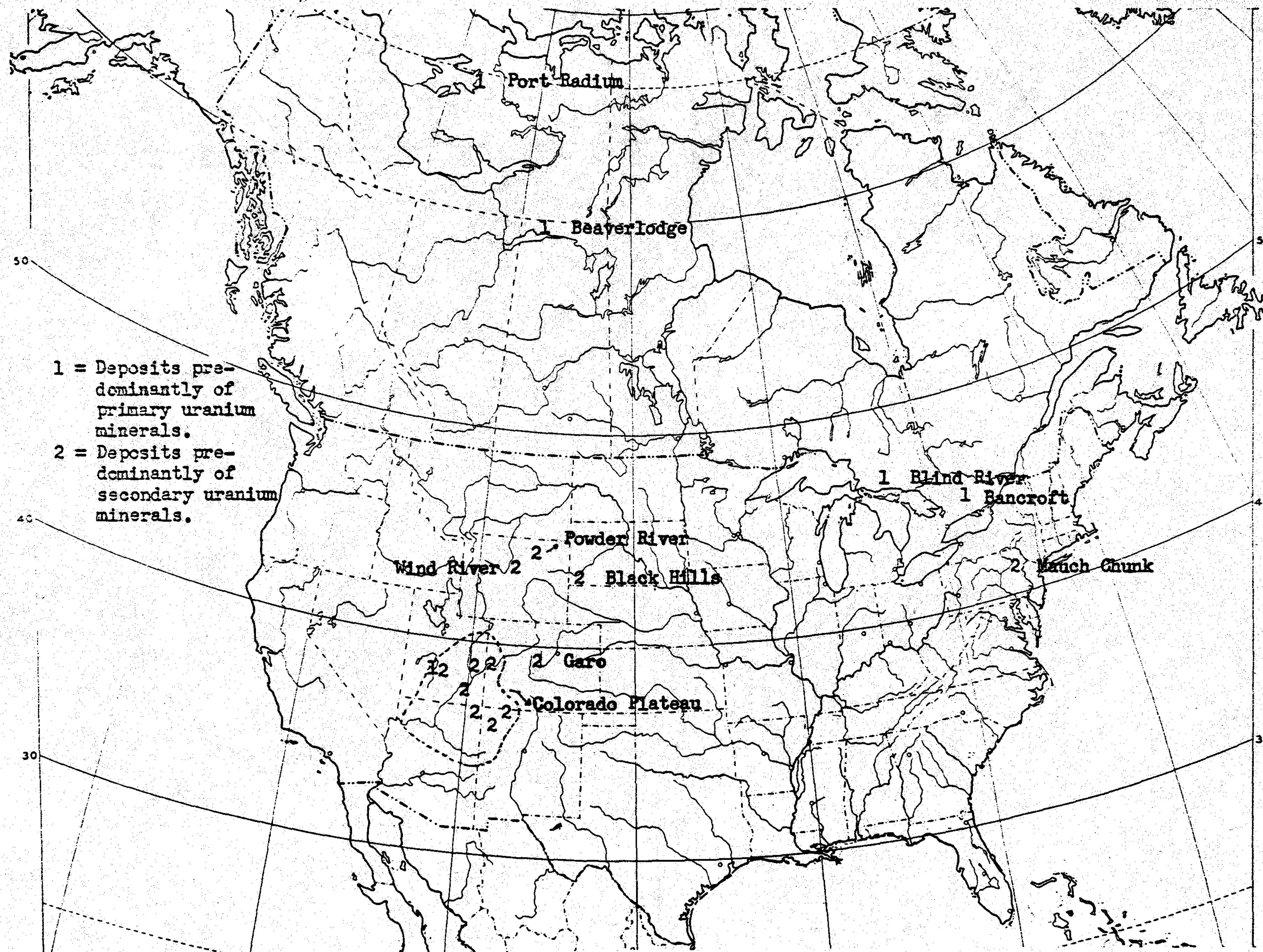

Principal Uranium Deposits in North America.

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PUBLICATIONS OF DIVISION OF GEOLOGY

Bulletin 71 of the Virginia Division of Geology, "The Geology and Oil Resources of the Rose Hill District, Lee County, Virginia," by Ralph L. Miller and J. Osborn Fuller, is for sale at the division office in Charlottesville. The price of this bulletin is $2.00; checks and money orders should be made payable to the division. Bulletins 69 and 70 will not be available for some time.

Reprint Series No. 17, "Geology of the Bergton Gas Field, Rockingham County, Virginia," by Robert S. Young and Wilbur T. Harnsberger, was received in May and may now be obtained free upon request to the Division of Geology. The article originally appeared in the March 1955 number of the Bulletin of the American Association of Petroleum Geologists.

"Records of Selected Wells on the Eastern Shore Peninsula, Virginia," by Allen Sinnott and G. Chase Tibbitts, Jr., which will be Mineral Resources Circular No. 3, will be distributed in July. This is another "free upon request" publication. It includes well logs and chemical analyses of ground water.

Mineral Resources Circular No. 4 will be "Ground Water Resources of the Roanoke-Salem District, Virginia," by Bruce F. Latta.

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DIVISION ACTIVITIES

April and May are the traditional meeting months for geologic societies, so the past weeks have been busy ones for the Division of Geology. In April staff members attended and presented papers before the Southeastern Section of the Geological Society of America, at Durham, N. C., and in May before the Section of Geology, Virginia Academy of Science, at Harrisonburg.

Also in May Harrisonburg served as the headquarters for the joint field conference co-sponsored by the Appalachian Geological Society, the West Virginia Geological Survey, and the Division of Geology. The conference, attended by about 100 geologists from six states and the District of Columbia, was a notable success. This is the largest group of geologists ever to assemble in Virginia.

In addition to these special activities division geologists have carried on the usual program of service to the people of Virginia, service which grows with increasing requests for information and assistance.

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RECENT ARTICLES

Several articles on Virginia geology have appeared since the publication of the last number of VIRGINIA MINERALS. The April issue of the Bulletin of the Geological Society of America includes "Geology of Catoctin Mountain, Maryland and Virginia," by John C. Whitaker; in the May issue of the same journal is "Geology of the Blue Ridge Region in Central Virginia" by Robert O. Bloomer and Harry J. Werner.

"Geology and Mineral Deposits of the James River-Roanoke River Manganese District, Virginia," is the subject of United States Geological Survey Bulletin 1008, by Gilbert H. Espenshade. This bulletin may be purchased for $6.00 from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.

The guidebook prepared for the joint field conference in the Harrisonburg area, mentioned in the April issue of VIRGINIA MINERALS and elsewhere in this issue, is for sale at a price of $1.00 by the Virginia Division of Geology. In addition to a road log the guidebook contains detailed descriptions of the stratigraphy and structure of the area visited, plus abstracts of the technical papers presented at the conference.

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METAL PRICES

The following metal prices, except for manganese, are from the June 1955 issue of the Engineering and Mining Journal. These are May averages. The manganese price is that paid by the Office of Defense Mobilization.

Copper, electrolytic, domestic refinery	35.700
Lead, common, New York	15.000
Lead, common, St. Louis	14.800
Manganese, long ton unit (22.4 lbs), 40% Mn, dry wt, base price	$ 2.30
Titanium, grade A, max. 3% iron	$ 3.95
Zinc, Prime Western, East St. Louis	12.000

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